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D E C I S I O N
of 5 March 1999

Case Number: T 0594/98 - 3.2.4

Application Number: 94904919.1

Publication Number: 0680550

IPC: F02D 41/06

Language of the proceedings: EN

Title of invention:
Method of operating an internal combustion engine

Applicant:
Orbital Engine Company (Australia) Pty. Ltd.

Opponent:
-

Headword:
-

Relevant legal provisions:
EPC Art. 56
EPC R. 67

Keyword:
"Inventive step - (yes) after amendment"
"Reimbursement of the appeal fee - (no)"

Decisions cited:
-

Catchword:
-

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Beschwerdekammern | Boards of Appeal | Chambres de recours

Case Number: T 0594/98 - 3.2.4

D E C I S I O N
of the Technical Board of Appeal 3.2.4
of 5 March 1999

Appellant: Orbital Engine Company (Australia) Pty. Ltd.
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Decision under appeal: **Decision of the Examining Division of the European Patent Office posted 23 January 1998 refusing European patent application No. 94 904 919.1 pursuant to Article 97(1) EPC.**

Composition of the Board:

Chairman: C. A. J. Andries
Members: H. A. Berger
M. Lewenton

Summary of Facts and Submissions

I. The appellant (applicant) has lodged an appeal against the examining division's decision of 23 January 1998 to refuse European patent application No. 94 904 919.1 for grounds based on Articles 52(1) and 56 EPC. The appeal was received on 17 March 1998 and the appeal fee was paid simultaneously. The statement of the grounds of appeal was received on 26 March 1998.

II. The following prior art documents have been taken into account during the examination procedure:

D1: DE-A-4 037 183

D2: Patent Abstracts of Japan, M-138, page 949, JP-A-2/5740

D3: US-A-4 023 359

The following prior art documents are cited in the Supplementary European Search Report:

D4: EP-A-0 499 207

D5: US-A-4 209 981

The following prior art documents are cited in the International Search Report:

D6: Patent Abstracts of Japan, M-131, page 588, JP-A-61/283735

D7: Patent Abstracts of Japan, M-110, page 1325, JP-A-4/183922

The examining division came to the conclusion that the subject-matter of claim 1 did not involve an inventive step having regard to document D1.

III. In a communication the board has drawn the appellant's attention to the following prior art documents:

D1a: GB-A-2 238 351 (same patent family as D1)

D8: "Automobiltechnisches Handbuch", Bussien, Technischer Verlag Herbert Cram, Berlin 1965, Abschnitt 1.5, Seiten 403 und 404

D9: "Handbuch der Kraftfahrzeugtechnik" Band 2, Wilhelm Heyne Verlag, München, 1976, Abschnitt 8.1.1, Seite 906

D10: EP-A-0 396 262

In a letter of response the appellant has cited the following documents:

D6a: US-A-4 612 770 (same patent family as D6)

D7a: US-A-5 207 058 (same patent family as D7)

Oral proceedings were held on 5 March 1999 during which the appellant filed new claims 1 and 8 and amended pages 2, 2a, 3 and 8.

IV. Claim 1 reads as follows:

"A method of operating an internal combustion engine having at least one cylinder with a piston therein and communicating with an exhaust system having a catalyst system therein, said method comprising injecting fuel directly into at least said one cylinder before the piston therein has reached top dead centre (TDC) position, said fuel being delivered at a rate higher than that required when the engine is operating normally, and retarding ignition of said fuel in said cylinder to a time after top dead centre (TDC) position of the piston in said cylinder and independent of the timing of the injection of the fuel whereby the exhaust gas from said cylinder is delivered to the exhaust system at a temperature sufficient to effect light-off of the catalyst system."

V. During the appeal proceedings the appellant confirmed that in a four stroke combustion engine the top dead centre position of the piston mentioned in claim 1 refers to the piston position between the compression stroke and the combustion stroke. The appellant furthermore agreed that a skilled person would be aware of the connection between a late ignition setting and the consequential increase of the exhaust gas temperature. A skilled person would also appreciate the necessity to compensate for the lower output resulting from such retarded ignition by increasing the fuel rate. The appellant however stated that he was aware of no single document or obvious combination of documents suggesting the features of claim 1. As is evident from the body of the specification the method of operation defined in claim 1 is mainly to be employed at engine start-up and idle, particularly in low ambient temperature conditions. In such conditions a skilled

person will consider too effective a fuel dispersion less advantageous due to the fact that fuel contacting the cold cylinder walls will tend to condensate there resulting in an overall poorer combustion efficiency with a less than optimum temperature of the exhaust gases. It will therefore take longer to reach the desired light-off temperature of the catalyst. Since the condensation phenomenon will be more outspoken the larger the time interval between injection and ignition the obvious choice will be to opt for a relatively short time interval between injection and ignition. Such a solution which involves retardation of both the injection and the ignition is basically what is described in document D1. Bearing this in mind it appears that the skilled person, when faced with the problem of effecting rapid light-off of the catalyst system at start-up and idle, would seek to maintain or reduce the time interval between injection and ignition, i.e. retard both these events, rather than to retard only the ignition.

VI. Requests

The appellant requested that the decision under appeal be set aside and a patent be granted on the basis of the following documents:

Claims: 1 and 8, filed during the oral proceedings on 5 March 1999;
2 to 7 and 9 to 17 filed with the letter of 5 January 1998.

Description: Pages 1, 4 to 7 as originally filed (WO-A-94/17293),

pages 2, 2a, 3 and 8 filed during the oral proceedings on 5 March 1999;

Drawing: Sheet 1/1 (Figures 1 and 2) as originally filed (WO-A-94/17293).

The appellant further requested reimbursement of the appeal fee.

Reasons for the Decision

1. The appeal is admissible.

2. *Allowability of the amendments (Article 123(2) EPC)*

2.1 Claim 1:

The features of claim 1 are disclosed in originally filed claims 1, 2 (fuel being delivered at a rate higher than that required when the engine is operating normally), claim 11 (an exhaust system having a catalyst system therein), claim 10 in conjunction with the description page 2, lines 25 to 27 (injecting fuel before the piston has reached top dead centre); page 2, lines 25 and 26 in conjunction with page 3, lines 21 to 26 and 30 (injecting fuel directly into the cylinder); page 4, lines 5 to 11 in conjunction with Figures 1 and 2 and claims 6, 7, 9 and 10 (retarding ignition to a time after top dead centre position of the piston - between 15° and 30° ATDC - independent of the timing of the injection of the fuel - between 60° and 80° BTDC); and page 2, lines 4 to 8 (whereby the exhaust gas from

said cylinder is delivered to the exhaust system at a temperature sufficient to effect light-off of the catalyst system).

2.2 Claims 2 to 17:

The claims 2 to 17 are based on originally filed claims 3 to 10 and 12 to 19.

2.3 Description:

The description (pages 2, 2a, 3 and 8) has been adapted to the new claim 1.

2.4 Therefore, the amendments made do not contravene Article 123(2) EPC.

3. *Novelty*

None of the prior art documents discloses a method of operating an internal combustion engine with all the features of claim 1 of the application. The method of claim 1 therefore is novel in the meaning of Article 54 EPC.

4. *Closest prior art*

The closest prior art is represented by the commonly known method of operating an ordinary, direct injection combustion engine with spark ignition and with an exhaust system having a catalyst therein.

5. *Problem and solution*

5.1 Problem:

The technical problem of the invention is to provide a method of operating an internal combustion engine which will assist in maintaining high exhaust gas temperatures and thus, where appropriate, achieve rapid light-off of the catalytic material in the exhaust system and maintain such a light-off condition whilst the engine is operating.

5.2 Solution:

Despite a simultaneous increase of the fuelling rate, retardation of the ignition results in a lower direct process efficiency, whereby is meant the conversion of energy from fuel into mechanical work. On the other hand this means that quite a high level of thermal energy is available in the exhaust gas to heat the catalytic treatment means. Owing to the less efficient combustion conditions, as resulting in particular from an ignition setting after top dead centre, gases with low oxidation temperature will be produced such as H and CO. These gases react with the catalytic material thereby further increasing its temperature and aiding it in rapidly reaching its light-off temperature. This effect is increased by injecting the fuel before top dead centre and independently thereof retarding the ignition to after the top dead centre.

6. *Inventive step*

6.1 It is commonly known that in a spark ignited combustion engine exhaust gas temperature will increase when ignition timing is retarded. It is also known to retard

ignition and increase fuelling as a combined means to speedily reach the light-off temperature of an exhaust gas catalyst in such a combustion engine. However, none of the available prior art documents discloses, in order to achieve a rapid light-off of the catalytic material in the exhaust system and/or to maintain such a light-off condition during engine operation, the method of injecting fuel directly into the cylinder before the piston has reached top dead centre and retarding ignition of the fuel in the cylinder to a time after top dead centre position of the piston independently of injection timing.

6.2 Documents D8 and D9 disclose in general that ignition usually occurs before top dead centre. If ignition takes place later then the engine output will be reduced and the exhaust gas temperature will increase. These documents confirm the common understanding that ignition after top dead centre is an exception and not the rule.

6.3 According to document D3 ignition timing is retarded in order to increase the exhaust gas temperature when the temperature of a thermal reactor falls to its reaction commencement temperature. Direct fuel injection is not indicated, nor is an increase of the fuel amount. The air/fuel mixture is apparently introduced into the cylinder via the intake valve (see Figures 1 and 3), i.e. fuel is introduced by indirect injection or by means of a carburetor. Fuel introduction into a cylinder of this four stroke engine therefore does not take place during the compression stroke but mainly during the suction stroke. The amount of retardation of the ignition timing is not indicated in document D3 and

it may therefore be assumed that the ignition is retarded only in the usual way, i.e. it is maintained before the top dead centre. Although a person skilled in the art will find in document D3 a solution to the above defined problem this solution is different from the claimed solution, and contains no hints or guidance in the direction of the latter.

6.4 The above ignition retardation scheme is also found in document D4 which likewise discloses retardation of the ignition timing in order to increase exhaust gas temperature and speed up the reaching of the light-off temperature of the catalyst. However, ignition timing is only retarded in the range before top dead centre (see Figure 3; column 7, lines 2 to 5, 52 and 53; column 10, lines 10 and 11; column 12, lines 17 to 20 and column 13, lines 29 to 35). Whereas document D4 does disclose an increase of the fuel rate in combination with retardation of ignition timing, fuel is injected into the intake branching pipes (see column 4, lines 54 to 56 and Figure 1) and not directly into the cylinder. In the case of this four stroke engine fuel is thus not introduced during the compression stroke before top dead centre and document D4 would therefore not lead a person skilled in the art to the claimed solution.

6.5 Document D5 discloses an engine with an exhaust gas purifying device, and with the same purpose of increasing the exhaust gas temperature the engine operation scheme again relies on a combination of retarding ignition timing and increasing the amount of combustible matter in the purifying device by enriching the air-fuel mixture introduced into the cylinder. In

this device also secondary air may be supplied into the exhaust gases fed to the purifying device and a separate spark plug is provided in the purifying device for ignition of the mixture therein. No specific information is given on the extent to which the ignition timing is retarded. However, if the intention would have been to retard ignition to after top dead centre one would have expected to find a clear statement to this effect in D5, since such an extreme retardation could not be considered as part of the normal practice but rather would amount to a most unusual or unconventional method step. No such statement is found. Furthermore, fuel is introduced into the intake system by a carburetor (see column 2, lines 26 to 32), i.e. not during the compression stroke before top dead centre. This prior art therefore again cannot lead to the method of claim 1.

6.6 Document D6a (D6) relates to a turbocharged engine having an exhaust purifier in the exhaust system. Here also it is proposed to retard the ignition timing and to increase the amount of fuel in order to attain a rapid warm-up of the exhaust gas purifying unit (see column 3, lines 32 to 40). Although it must be considered normal practice for a person skilled in the art to delay ignition and although it remains unclear in document D6a to which extent the ignition is delayed, normal practice would be to maintain ignition before the top dead centre, see the above sections 6.3 to 6.5. Furthermore, the injection valves (14) are located upstream of the intake valve (2) and fuel is therefore not injected directly into the cylinder during the compression stroke before top dead centre.

6.7 Document D7 (document D7a is not prepublished and therefore not state of the art according to Article 54(2) EPC) discloses an internal combustion engine where, according to the embodiment of Figures 1 and 2, a first amount of fuel (Ij1) is both injected and ignited (Ig1) before the top dead centre (between the compression and the combustion stroke). A second amount of fuel (Ij2) is injected after said top dead centre and ignited before the next following top dead centre. According to the embodiment of Figure 2 also a third amount of fuel (Ij3) is injected before the next following top dead centre. Again the fuel injection occurs close to the ignition timing. According to the embodiment of Figures 3, 7 and 8 an additional spark plug (66, see Figures 7 and 8) is provided in the exhaust passage 18 and activated after the next top dead centre. Such a method is completely different from the claimed method and the teaching of document D7 cannot fairly lead a person skilled in the art to the method according to claim 1.

6.8 Document D10 discloses a two stroke engine with a catalyst in the exhaust gas system. In order to reduce the start-up time of the catalytic converter and to rapidly increase the exhaust gas temperature, means are provided to separate the hot blowdown gases and the scavenging gases. Document D10 does not describe a method of increasing exhaust gas temperature by solely retarding ignition timing and increasing the injected fuel amount.

6.9 Document D2 describes a method for rapid warming up a combustion engine, ensuring stable idling by increasing the fuel injection quantity and delaying the ignition

timing. The fuel injection valve (13) is, according to the drawing, located in the suction duct, with the risk of fuel "hangup" within the means used to deliver fuel into the cylinder. Fuel is therefore not injected directly into the cylinder, nor is fuel injected during the compression stroke before the top dead centre.

6.10 Document D1 (D1a), which was considered by the examining division as the most relevant prior art document, discloses a method of operating an internal combustion engine having at least one cylinder with a piston therein and communicating with an exhaust system having a catalyst system (14) therein. The method comprises injecting fuel directly (see injector 10) into said at least one cylinder at a rate higher than that required when the engine is operating normally (see D1, column 3, lines 53 to 55) and retarding ignition of said fuel to a time after top dead centre (TDC) position of the piston (see Figure 4 and description column 4, lines 6 to 13 and 18 to 23), whereby the exhaust gas from said cylinder is delivered to the exhaust system at a temperature sufficient to faster effect light-off of the catalyst system.

In particular transient conditions between cold engine idling conditions (both injection and ignition timing after top dead centre) and normal operation conditions (both injection and ignition timing before top dead centre), this system may involve injection before and ignition after the top dead centre. This particular case is however but a consequence of the disclosed teaching according to which a certain retard quantity is determined, depending on a temperature difference signal. In case the temperature of the exhaust gas is

lower than a reference temperature, a retard quantity common to the injection timing and the ignition timing (see claim 1) is determined. The relationship between injection and ignition timing is apparently an essential feature in this system and no hint is given to adjust ignition and injection timing independently of each other, e.g. to maintain injection timing before top dead centre while retarding ignition timing to after top dead centre.

6.11 Since none of the prior art documents D2 to D10 clearly discloses retardation of ignition timing to after top dead centre in a direct injection engine this state of the art cannot in combination with the above defined closest prior art or with the state of the art according to document D1, lead to the method of claim 1.

6.12 The method of claim 1 therefore involves an inventive step (Article 56 EPC).

7. In view of the above claim 1 is patentable under Article 52(1) EPC. Claims 2 to 17, the description and the drawings also meet the requirements of the EPC.

8. *Request for reimbursement of the appeal fee*

8.1 In his statement of the grounds of appeal the appellant argues that the first instance refusal of the application was based on a new ground on which the applicant had had no opportunity to comment. In the

appellant's opinion this amounts to a serious procedural violation, which as such justifies the appellant's consequent request for a reimbursement of the appeal fee.

8.2 The application was refused for lack of inventive step with respect to document D1. In the official communication dated 19 February 1997, the originally filed claims 1 and 2 were held to lack novelty vis-à-vis document D1. In the official communication dated 3 July 1997, the examining division rejected a fresh version of claim 1 (now including the features of originally filed claim 2) and moreover hinted, that even limitation of this claim "to a direct injection, e.g. two-stroke, engine would ... not render its subject matter inventive", see the first paragraph of section 3. The board sees this reference to a direct injection engine as a reference to document D1, meaning that here the examining division implicitly stated that it sees no inventive step over document D1. The board, therefore, as already brought forward in its communication dated 21 December 1998, does not see a substantial procedural violation in this case so that there is no reason to reimburse the appeal fee. Since further amendments to claim 1 were necessary during the present appeal proceedings reimbursement of the appeal fee cannot be made.

Order

For these reasons it is decided that:

1. The decision under appeal is set aside.

2. The case is remitted to the first instance with the order to grant a patent in the following version:

Claims: 1 and 8, filed during the oral proceedings on 5 March 1999;
2 to 7 and 9 to 17 filed with the letter of 5 January 1998.

Description: Pages 1, 4 to 7 as originally filed (WO-A-94/17293),
pages 2, 2a, 3 and 8 as filed during the oral proceedings on 5 March 1999;

Drawing: Sheet 1/1 (Figures 1 and 2) as originally filed (WO-A-94/17293).

3. The request for reimbursement of the appeal fee is refused.

The Registrar: The Chairman:

N. Maslin C. Andries